Science, Service, Stewardship

NOAA

NOAA FISHERIES SERVICE

Microworlds Videos - Supplemental Material

U.S. Department of Commerce | National Oceanic and Atmospheric Administration | National Marine Fisheries Service

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Alaska Fisheries Science Center
7600 Sand Point Way N.E.
Seattle, Washington 98115-6349

September 1, 2010

Dear Educators,

For the past 2 years, we have been working on a career link for the Science & Technology Concepts (STC) Microworlds Unit. The enclosed materials were designed to supplement the STC Microworlds science kit, though they can also be used independently. Through these materials, we hope to help students make a connection between what they are learning in class and what scientists do every day.

The enclosed DVD contains three short videos, titled:

- "What Do Marine Mammals Eat?"
- "How Old is a Fish?"
- "Why do Fish Get Sick?"

Each video highlights a NOAA scientist and how microscopes are used in his or her research. We suggest that you review the videos before showing them to your class. They do not have to be shown in the order presented but they are set up to show a progression from the macro-environment to the micro-environment.

We have also included a pamphlet with supplemental material. These materials include:

- Job descriptions and biographical information on the scientists
- Frequently asked questions
- Internet and print resources for more in-depth information on the subjects of the videos
- Information about the microscopes used by the scientists
- Glossary
- Images of otoliths
- A map of the distribution of the northern fur seal
- How the educational material relates to Washington State educational standards and Ocean Literacy Principles

We would greatly appreciate any constructive feedback.

Please feel free to contact us if you have any questions. Have fun!

Sincerely,

Lisa Hiruki-Raring & Pam Goddard

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CONTENTS

INTRODUCTION

During the past decade, the National Oceanic and Atmospheric Administration (NOAA) has recognized the need to take a broad approach to increasing environmental and ocean literacy and raising awareness about NOAA science and careers. In its NOAA Science Extensions project, the Alaska Fisheries Science Center (AFSC, part of NOAA's National Marine Fisheries Service), is developing curricula to integrate with science kits already in use in Seattle area schools. Our goals in developing science curricula involving NOAA science are to increase awareness of the science and careers at NOAA, promote environmental and ocean literacy in students and teachers, inspire youth to pursue scientific careers, and improve the public's understanding and appreciation of NOAA's missions and how NOAA research connects to their everyday lives.

NOAA Science Extensions for the Science & Technology Concepts Program (STC) Microworlds science kit will provide real-world examples of how microscopes are used in NOAA. Our curriculum extension will show practical applications of principles learned in the classroom, while requiring minimal preparation by the teacher. The NOAA Microworlds Science Extension is a series of three short videos (8-10 minutes), each featuring several students and one NOAA scientist and highlighting the NOAA scientist's work. Each scientist discusses how his or her work relates to microscopes, and why the questions that are being asked are important to know. This supplemental material packet gives additional information about the scientists and their work, microscopes, additional resources, and a glossary.

JOB DESCRIPTIONS

Tony Orr

Tony Orr is a marine mammal biologist at the Alaska Fisheries Science Center in Seattle, Washington. Tony's division, the National Marine Mammal Laboratory, studies marine mammal populations in the waters off the coasts of Alaska, Washington, Oregon, and California. Tony and his colleagues study all aspects of marine mammal life history including births, deaths, feeding habits, distribution, haulouts, and population changes.

Tony's job is to study the California sea lions and northern fur seals on San Miguel Island, off the coast of southern California. In addition to counting animals, Tony studies the foraging (feeding) behavior of California sea lions on San Miguel Island. The information that is collected by Tony and his colleagues is stored in databases at NOAA. Part of Tony's time is spent making sure the data collected is accurate and of the highest quality.

For Tony, studying the feeding habits of California sea lions is not just for managing sea lion populations. California sea lions occupy the same waters and consume many of the same prey species that humans do. Understanding the feeding habits of these animals is critical to minimize negative interactions between people and sea lions, both direct (e.g. sea lions caught in fishing gear) and indirect (e.g. sea lions competing with fishermen for fish). Tony hopes that by studying these amazing animals, he will gain insight into the health of the ecosystem and be able to determine if humans have a negative impact on it.

Chris Johnston

Chris Johnston is a fisheries biologist at the Alaska Fisheries Science Center in Seattle, Washington. Chris and his colleagues determine the ages of commercially harvested fish caught in the Bering Sea and the Gulf of Alaska. Fish are aged by examining a pair of bony structures that all marine and freshwater fish have. These bones or ear stones are called otoliths, and are found inside the fishes' head. Chris examines otoliths under a dissecting microscope and counts the rings on the surface like you would count the rings in a tree. The lab ages about 30,000 otolith samples each year, and has seven people who age otoliths full-time. Otoliths are obtained during the summer fishing surveys conducted by the Alaska Fisheries Science Center.

The ages of the fish are entered into a computer database and are used by scientists who decide how many fish can be caught each year. It is important to know how old the fish are that fisherman are catching because scientists and managers can use that information in setting limits on how many fish can be caught and how old the fish need to be before they are caught. If fisherman caught all of the fish before they were able to reproduce we would run out of fish very quickly.

Chris has other duties as well – he enjoys doing education and outreach work, talking with groups of junior high and high school students who visit the Alaska Fisheries Science Center. He also goes out to sea on fisheries research cruises; it's not unusual for Chris to spend up to a month out at sea. On these research cruises he collects otoliths and other biological samples for researchers back at the lab in Seattle.

Carla Stehr

Carla Stehr is a fisheries biologist at the Northwest Fisheries Science Center in Seattle, WA. Carla often works with a team of scientists investigating the impacts of man-made and natural toxins (e.g., chemical contaminants and harmful algal blooms) on fishery resources, protected species and the quality of marine habitat. Carla's specialty is studying the cell structures of marine organisms with light and electron microscopes.

Some of Carla's duties include collecting samples – for example, riding on boats or walking on beaches and working with sample collecting gear such as plankton nets, fishing nets, and sediment grabs; identifying organisms; taking measurements; preparing samples; and recording observations. She also does laboratory work – for example, designing and conducting laboratory studies, keeping records, preparing chemicals; processing samples; examining samples with microscopes; taking photographs. Another part of her job includes office work like processing data, writing papers, and telling other people about the study results.

Carla likes being a scientist because she likes being a detective to find out how things work. She became a fisheries biologist because she was fascinated by the variety of colors, shapes and sizes of aquatic plants and animals and how they interact with each other and their environment. Carla thinks it's incredible how a tiny fish egg divides into two cells, then four, and then soon grows into a fish with a huge number of very different cells! Seen up close with a microscope, the individual cells are also very beautiful and have their own set of mysteries to be solved.

BIOGRAPHIES

Tony Orr

Current Job: Wildlife Biologist, National Marine Mammal Laboratory

Job Location: Alaska Fisheries Science Center, NOAA, Seattle, WA

High School Education: Columbus, Ohio

College Education: Ohio State University, BS; Fresno State University, MS; University of Washington, PhD

Favorite Job: Graduate student – the pay is horrible but I get to learn a lot

Least Favorite Job: Busboy at a restaurant

When did you first become interested in the sciences?
Ever since I was a kid; when I was young I was always interested in the outdoors and in studying animals.

What other jobs did you hold before working for NOAA?
After I graduated from Ohio State I went to South Carolina and worked on a project looking at the diet of fish in a cooling reservoir at a nuclear reactor site. My next job was back in Ohio working as a research scientist at pharmaceutical company. But my days were filled in the laboratory and I just yearned to get out doors again so I headed back to school to study sea lions. I have also worked as a group leader for outreach program, teaching assistant, among several other positions

What do you do for fun?
I like to do a lot of outdoor activities. During the spring, summer, and fall when I am not in the field, I like to go hiking and camping. During the winter I enjoy going snowboarding and cross-country skiing with friends. I am a volunteer for Inner City Outings where we take elementary and middle school kids on outings and engage in activities, such as snowshoeing, hiking, canoeing, etc. I am also a bootcamp fitness trainer. I enjoy keeping in shape and helping others achieve their fitness goals. I love to travel and learn about different countries, cultures, languages, and cuisines. I am an amateur photographer and try to express my experiences in photos. When I am not on the go I like to relax by watching movies.

Chris Johnston

Current Job: Age & Growth Laboratory Technician

Job Location: Alaska Fisheries Science Center, NOAA, Seattle, WA

High School Education: Everett, WA

College Education: Western Washington University (Drama and Dance); Cornish College of the Arts (Drama and Dance); University of Montana (Biology & Political Science); University of Western Washington (Biology).

Favorite Job: Being involved in new and interesting projects with the Age and Growth Program, Alaska Fisheries Science Center, NOAA.

Least Favorite Job: I don't have one.

When did you first become interested in the sciences?
When I was a kid; I have always been interested in how things work, and what makes things work.

What other jobs did you hold before working for NOAA?
I have worked on a number of fishing boats, tugboats, a cruise ship, several restaurants, and I had a stint with the New York City Opera in Los Angeles. I guess I have always been attracted to the sea. My first job working in fisheries was with the International Pacific Halibut Commission.

What do you do for fun?
I work on and collect vintage Jaguar cars' and I am the President of the Jaguar Drivers and Restorers Club of North America. Also, I have been involved in some locally produced films in Seattle where the film producers wanted to use my vintage Jaguar. I am also a beekeeper and I enjoy cooking.

Other Comments:
I still enjoy working at NOAA where I determine the age of commercially important fish species caught off the coast of Alaska and the Bering Sea. In a world where so many people claim to hate their jobs, or not particularly like what they do for employment, I find that I am very lucky because I have a job that I still truly enjoy and look forward to almost every day.

Carla Stehr

Current Job: Fisheries Biologist, Electron Microscopy Laboratory

Job Location: Northwest Fisheries Science Center, NOAA, Seattle, WA

High School Education: Olympia, WA

College Education: Evergreen State College, BA; University of Washington, MS

Favorite Job: What I do now!

Least Favorite Job: Cleaning apartments.

When did you first become interested in the sciences? 5th grade

What other jobs did you hold before working for NOAA?
In high school my first jobs were picking blueberries and babysitting.

My first summer job in college was checking Washington State Initiatives to make sure the signatures were from registered voters. I had the night shift from 5 pm to midnight. The next summer I worked for an apartment manager sorting mail and cleaning apartments after people moved out. My last two summer jobs during college were with the Washington State Department of Ecology, testing water samples and sorting bugs from stream water.

During my last year of college I had an Internship at the Field Museum of Natural History in Chicago cataloging clam and snail shells for the Museum's invertebrate collection.

My first year after college, I had a couple of temporary jobs at the University of Washington's Department of Oceanography. One job was working for a physical oceanographer studying water quality in Puget Sound. At that time (way before personal computers) data was "key punched" onto cards and fed into a mainframe computer. I did lots of key punching. I also did some water testing, and occasionally rode on a boat and collected water samples. The second job was in a biological oceanography lab, and this time I sorted fish eggs from plankton samples, and helped do beach surveys to estimate the how many worms, clams, barnacles and shore crabs lived on beaches close to pulp mills.

After that, I found a full time, permanent job at NOAA in the Electron Microscopy Lab, and I've been there ever since!

What do you do for fun?
I love to be outside and explore tide pools and go camping. I take lots of photographs of nature. I love gardening too, so every year I plant a big garden with vegetables and berries and fruit trees. And most of all, I like to make art. Many of the things I see or photograph when I'm outside or looking through a microscope find their way into my art.

FREQUENTLY ASKED QUESTIONS

Tony Orr – Marine Mammal Food Habits

Does Tony really taste poop?
No, the outtake video clip was just a joke! Tony has never tasted poop.

Are they allowed to touch the seals and sea lions?
Yes, Tony and the other scientists have special permits that allow them to touch the seals and seal lions to collect scientific data. If you do not have a permit you are not allowed to touch marine mammals. They are protected by the Marine Mammal Protection Act.

Do they ever collect data from dead animals on the beach?
Yes, scientists do collect stomachs from dead animals on the beach.

How else do scientists study marine mammal food habits?
- *Direct observations*: Using eyes with or without the aid of binoculars, spotting scope, camera, using a video camera that can be attached to the animal
- *Indirect methods*: Collection of the colon (part of the large intestine) or the stomach from a dead animal (marine mammals have been protected since 1972, so we can't kill them to collect these organs anymore). Collection of enemas, feces (scats), spewings, or lavage (having an animal throw up). Scientists can also use genetics to determine what an animal has eaten, as well as whether the predator is male or female. Scientists use biochemical methods (analyzing blood or fat, or other tissues) to look at food habits too.
-*Instrumentation*: Scientists put satellite tags on animals to determine where they are going, and use time-depth recorders to look at their diving behavior (how deep they dive, how long their dives are). Scientists use stomach sensors to determine when marine mammals eat.

For many marine mammals that feed offshore and at depth, the indirect methods are used. Of course, there are a lot of assumptions we make when using indirect methods, so if we can improve these techniques or come up with new ones, then we'll have a better understanding about the foraging ecology of marine mammals.

Where are the Pribilof Islands?
The Pribilof Islands are in the Bering Sea, west of Alaska. There are five islands: St. Paul, St. George, Otter, Walrus, and Sea Lion Rock. St. Paul and St. George are the two largest islands.

Where is San Miguel Island?
San Miguel Island is one of five islands in the Channel Islands National Park off the coast of California. The islands are only accessible by boat or airplane.

FREQUENTLY ASKED QUESTIONS

Chris Johnston – Fish ageing

Do you have to kill fish to age them?
Unfortunately, yes. You do have to kill fish to remove their otoliths.

Do big fish have big otoliths and small fish have small otoliths?
Not necessarily; salmon have fairly small otoliths for being such large fish. The answer depends on the species of big fish. Albacore tuna is a large fish with very small otoliths when compared to the size of the fish. On the other hand, Pacific cod and pollock have very large otoliths in relation to their size.

Where do yelloweye rockfish live?
They live in the Pacific Ocean between Baja California and the Aleutian Islands in Alaska. They can grow to 91 cm (36 in) and live in water as deep as 400 m. In 2002, yelloweye rockfish were declared overfished and measures were taken to reduce their catch.

How do you find an ear stone/otolith?
They are located inside the fish's head right behind the eyes. We usually cut down from the top of the head to locate the ear stones.

How do you know if it's a boy or girl fish?
We cut them open and look for their reproductive organs (ovaries or testes).

When you bring the fish up in the net do they die instantly?
The fish that come up from very deep water die fairly quickly because they cannot handle the rapid change in pressure. Other fish are still alive when they are brought on board the vessel. Scientists make every attempt to return the live fish to the ocean as quickly as possible. Maybe some day one of you will discover a way to study fish ages without killing the fish.

Do all fish have otoliths?
No, not all fish have otoliths. Cartilaginous fishes such as sharks, rays, and skates do not have otoliths.

Do humans have otoliths?
Yes, mammals including humans have otoconia which are similar to otoliths. Otoconia of humans are very small (3-30 microns). They can only be seen with a high powered microscope. Otoconia are small crystals made of calcium carbonate found in the inner ear. They help humans detect gravity and forward/backward motion. If human otoconia become dislodged they can cause symptoms similar to sea sickness.

How do you know if the fish ages are accurate?
For most of the fish species that we age, we are confident that the fish ages we produce are very accurate. This depends, of course, on the species that we are ageing. Some fish are extremely hard to age and some are not very difficult. In our fish ageing lab, we have a method for checking the ages that we call quality control. For every group of fish otoliths a scientist ages,

20% of the otoliths are re-examined by another experienced age reader. If the results of these tests are good and both age readers get the same ages or are in agreement with each other, then the data are considered accurate. If the results of this test are not good because the age readers get different ages, the otoliths will have to be re-aged and another test will be conducted.

Are the rings on the otoliths similar to the rings on a tree?

The growth rings of an otolith are very similar to the rings on a tree. The age of a tree can be determined by counting the growth rings. Each spring's new growth of a tree is seen as an area of light-color wood surrounded by a darker area, which is the result of the tree's fall transition. Ring size tends to vary, depending on the environmental conditions the tree is exposed to just like in fish otoliths. In the otoliths of fish growth rings do and can vary with each year of growth, and counting these rings can be somewhat challenging to the age reader.

FREQUENTLY ASKED QUESTIONS

Carla Stehr – Scanning Electron Microscope

Will a scanning electron microscope explode if there is water in the sample?
No, but the water will vaporize and this can cause the sample to explode!
http://www.bacteria-world.com/what-is-SEM.htm

Why is it bad to flush medicine down the toilet?
When you flush medicine down the toilet it goes to a waste-water treatment plant. These plants remove mostly solids from the waste-water. They are not designed to remove prescription medicine from the water. After passing through the waster water treatment plant the water is released into Puget Sound. If you flush medicine down the toilet it will probably end up in Puget Sound.

What should we do with unused medicine?
1. Learn about disposing medicine at: http://www.medicinereturn.com/.
2. Gather your unwanted medications. See **YES/NO** list on the website to find out which items can be returned. Leave items in their original containers. Mark out any personal information if you wish.
3. Bring medications to a participating pharmacy or law enforcement office. See list of locations to find a participating pharmacy near you. http://www.medicinereturn.com/return-your-medicines/What-to-return/return-your-medicines/return-locations
4. Deposit medications into the secure bin marked for medication return.

Or

1. Keep the medication in its original container.
2. Modify the medications to discourage consumption by adding something unappealing, such as kitty litter or sawdust. Do not crush the pills.
3. Seal and conceal. Tape the container lid shut with tape, place in a sealable bag, then place in a non-transparent container to ensure that the contents cannot be seen.
4. Discard the container into the garbage. Do not place in the recycling bin. Make sure your trash cannot be accessed by children, pets, or others who might be looking in the garbage for drugs.

What can kids do to help keep our water cleaner?
Visit Puget Sound Starts Here website. http://www.pugetsoundstartshere.org/
Take your car to a car wash. Don't wash it in the streets.
Pick up pet waste.
Don't use chemicals on your lawn.

RESOURCES

Tony Orr

NOAA
Alaska Fisheries Science Center, National Marine Mammal Laboratory
http://www.afsc.noaa.gov/nmml/

Northwest Fisheries Science Center, Marine Mammal Ecology
http://www.nwfsc.noaa.gov/research/divisions/cbd/marine_mammal/marinemammal.cfm

Marine Mammal Protection Act
http://www.nmfs.noaa.gov/pr/laws/mmpa/

General Information
National Geographic Crittercam
http://www.nationalgeographic.com/crittercam/

Webcams
Farallones Webcam
See marine mammals and seabirds off the coast of California
http://www.calacademy.org/webcams/farallones/

Monterey Bay Aquarium Webcam
http://www.montereybayaquarium.org/efc/efc_lotb/webcam.aspx

Alaska Sea Life Center, Chiswell Island Steller Sea Lion Live Camera
http://www.alaskasealife.org/New/research/index.php?page=chiswell.php

Race Rocks Webcam, See pinnipeds and seabirds in the Straight of Juan de Fuca
http://www.racerocks.com/racerock/video1frame.htm

Whale Poop
Worst Jobs in Science #10, 2007: Whale Feces Researcher
http://www.popsci.com/scitech/article/2007-06/worst-jobs-science-2007

Dogs and Whale Poop
http://www.seattlepi.com/local/271110_orcadogs22.html

King 5 News: DNA Analysis of Whale Poop
http://www.king5.com/news/local/DNA-analysis-of-whale-poop-brings-surprising-results--87699492.html

UCN Redlist of Threatened Species
Learn about the status of the northern fur seals and many, many other species.
http://www.iucnredlist.org/

Alaska Sea Grant, Northern Fur Seal
http://seagrant.uaf.edu/marine-ed/mm/fieldguide/fur-seal.html

The Cephalopod Page, Learn All About Squid, Octopus, Nautilus, and Cuttlefish
http://www.thecephalopodpage.org/

Fishbase, Database of Fish From Around The World
http://fishbase.org/search.php

National Park Service, San Miguel Island
http://www.nps.gov/chis/planyourvisit/san-miguel-island.htm

Aleutian Pribilof Islands Association
http://www.apiai.com/history.asp?page=history

RESOURCES

Chris Johnston

NOAA
Alaska Fisheries Science Center, Age Reading Game
http://www.afsc.noaa.gov/refm/Age/interactive.htm

Alaska Fisheries Science Center, Age and Growth Program
http://www.afsc.noaa.gov/REFM/Age/Default.htm

Yelloweye Rockfish
http://www.afsc.noaa.gov/groundfish/RockfishGuide/Rockfish_Pages/Yelloweye_rockfish.htm

General
Washington Department of Fish and Wildlife, Yelloweye Rockfish Regulations
http://wdfw.wa.gov/fish/rockfish/yelloweyeprotect.htm

International Pacific Halibut Commission, Otolith Aging
http://www.iphc.washington.edu/staff/joan/otolith.HTM

Fish and Wildlife Research Institute, Florida Fish and Wildlife Conservation Commission
http://research.myfwc.com/features/view_article.asp?id=21978

NASA uses fish to fight space sickness.
http://www.space.com/missionlaunches/toadfish-space-motion-sickness-100305.html

Otolith Research Laboratory, Bedford Institute of Oceanography, Canada
http://www.marinebiodiversity.ca/otolith/english/determine.htm

Wild Education, Canadian Wildlife Federation, Scales Tell Tales
http://www.wildeducation.org/programs/fish_ways/activity/scales.asp

Dizziness and Balance, Human Otoliths
http://www.dizziness-and-balance.com/disorders/bppv/otoliths.html

Human Otoliths
http://www.tchain.com/otoneurology/disorders/bppv/otoliths.html

RESOURCES

Carla Stehr

NOAA
Carla's Program at the Northwest Fisheries Science Center
http://www.nwfsc.noaa.gov/research/divisions/ec/ecotox/index.cfm

Northwest Fisheries Science Center
http://www.nwfsc.noaa.gov/

General
Bugscope
http://bugscope.beckman.illinois.edu/
The Bugscope project provides FREE interactive access to a scanning electron microscope (SEM) so that students anywhere in the world can explore the microscopic world of insects. This educational outreach program from the Beckman Institute's Imaging Technology Group at the University of Illinois supports K-16 classrooms worldwide.

Cells Alive! How Big is a…?
http://www.cellsalive.com/howbig.htm

Iowa State University, What is an Scanning Electron Microscope and how does it work.
http://www.mse.iastate.edu/microscopy/home.html

Iowa State University, FREE on-line, interactive, web based scanning electron microscope. Materials Science and Engineering, Extended Classroom for Enhanced Learning.
http://www.mse.iastate.edu/excel/

Dennis Kunkel, Scanning Electron Microscope images
http://education.denniskunkel.com/

Unwanted Medicine Return Program
http://www.medicinereturn.com/

Puget Sound Starts Here
http://www.pugetsoundstartshere.org/

Puget Sound Partnership
http://www.psp.wa.gov/aboutthepartnership.php

King County Stormwater Runoff
http://www.kingcounty.gov/environment/waterandland/stormwater/introduction/stormwater-runoff.aspx

NOAA Coastal Storms Program/Stormwater information
http://coastalstorms.noaa.gov/stormwater/

Oregon State, Tips for Keeping Salmon Healthy
http://www.oregon.gov/OPSW/partners/partner.shtml

Washington Department of Ecology information on copper brake pads.
http://www.ecy.wa.gov/biblio/0903057.html

Copper and Salmon
http://extension.oregonstate.edu/news/story.php?S_No=446&storyType=news

Chris Dunagan Blog, Washington State Bans Copper Brake Pads
http://pugetsoundblogs.com/waterways/2010/03/10/washington-is-first-to-tackle-toxic-copper-in-brakes/

Books

Bourely, France. Hidden Beauty: Microworlds revealed. Harry N. Abrams, Inc. Publisher, New York. 2002.

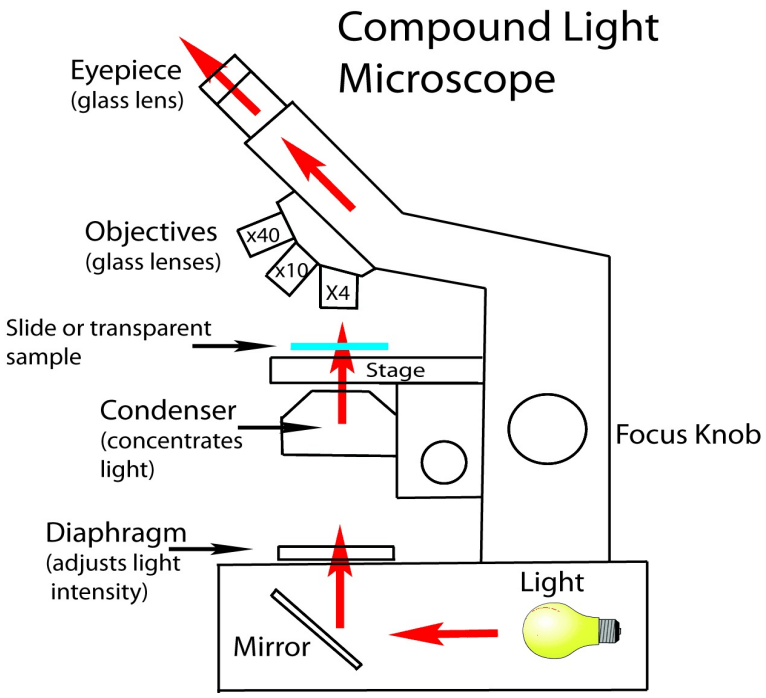
Kramer, Steven, and Dennis Kunkel. Hidden Worlds: Looking through a scientist's microscope. Houghton/Mifflin, Boston, MA. 2001

Tomb, Howard and Dennis Kunkel. MicroAliens. Dazzling Journeys with an Electron Microscope. Farrar, Straus and Ciroux: New York, 1993.

MICROSCOPES

Compound Microscope

A compound microscope has more than one lens. The second lens magnifies the images from the first lens. The first microscopes only had one lens. Some of the best compound microscopes have the ability to magnify up to 2000x. Light is transmitted through a thin sample (such as a tissue section) or transparent object, creating a two-dimensional image.
Cost: $50 - $15,000



Dissecting Microscope or Stereomicroscope

A dissecting microscope is also referred to as a stereomicroscope or stereoscope. Light is used to illuminate the surface of the sample. Some stereomicroscopes also transmit light through transparent objects. The lenses are arranged to produce a stereoscopic or three-dimensional image. Chris's microscope can magnify up to 60 times.

The binocular dissecting microscopes used by Chris are designed so that the person using the microscope for more than 3 or 4 hours won't hurt their necks, wrist or back.

The two lenses used on the dissecting microscope include the eyepiece and the objective. Different powers of magnification can be used for both lenses. The dissecting microscope used by Chris has eyepieces that magnify an image 10 times its original size. If Chris uses a 4x objective, then the total magnification would be 40 times original size. Chris's microscope magnifies up to 60 times. If he needs to examine the otoliths even closer, he uses a video camera system that displays the image on a large video screen.

Cost: $50 - $15,000

Scanning Electron Microscope

Carla uses a scanning electron microscope (SEM). The two most common types of electron microscopes are: scanning electron microscope and transmission electron microscope. The scanning electron microscope examines the surface of a specimen, creating a three dimensional-like image similar to what can be seen with a stereomicroscope only with greater depth of field and at higher magnifications. A transmission electron microscope produces an image by passing electrons through a very thin sample, resulting in a two dimensional image similar to what may be seen with compound microscope but at much higher magnifications.

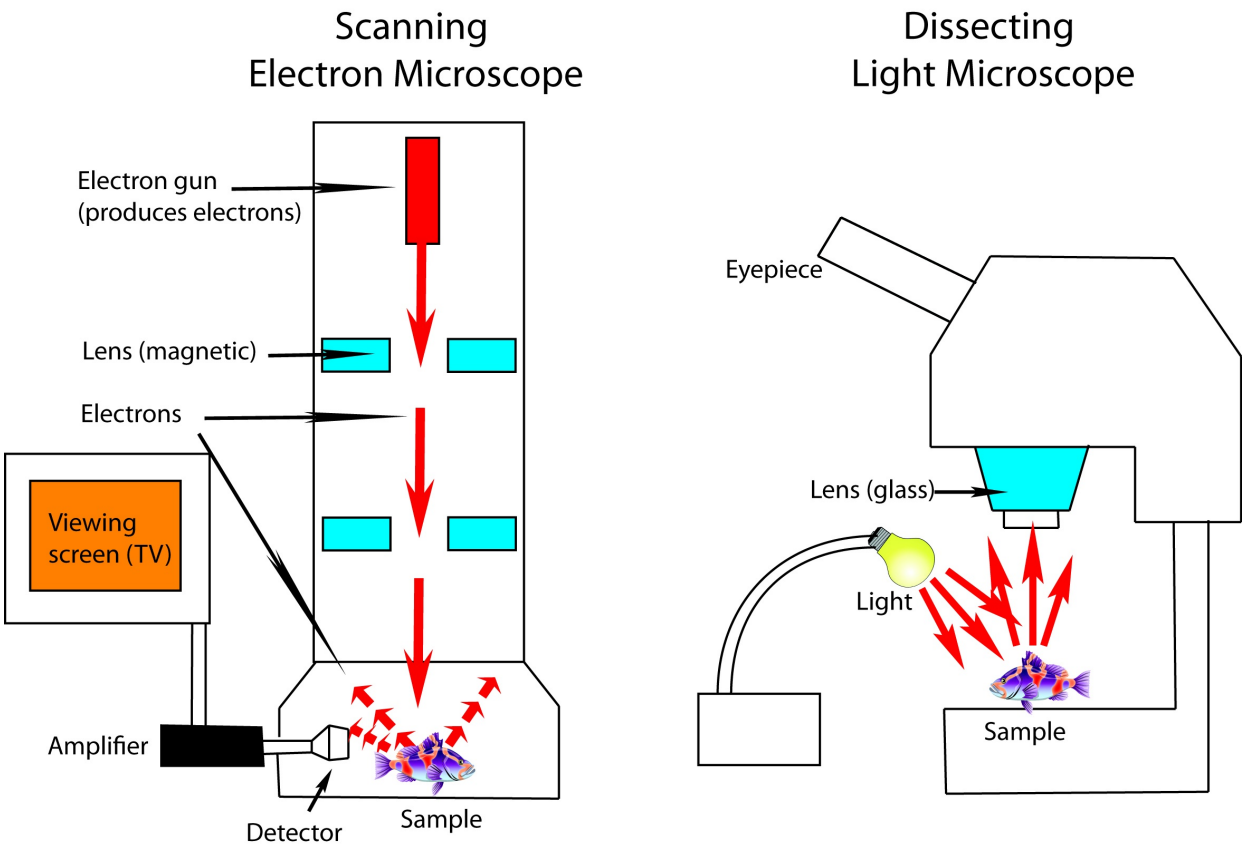
Scanning electron microscopes use a beam of electrons to examine specimens. Conventional SEMs, like the one Carla uses, does this in a vacuum because air molecules interfere with the path of electrons. Other SEMs have been developed that can now image wet samples under a partial vacuum. The electrons produced by the SEM cause more electrons to be emitted from the surface of the sample. Using technology much like a television, the electrons coming from the sample surface are colleted with a detector and amplified on a TV or computer screen.

Because the samples are examined in a vacuum, they cannot contain any moisture. Moisture vaporizes in a vacuum and can cause the sample to crack or explode.

Electron microscopes can examine samples at much higher magnifications than light microscopes because electron wavelengths are much shorter than the wavelengths of light. The SEM Carla uses can magnify an object up to 300,000 times, but the magnifications that work best for biological samples range from 30 to 50,000 times.

Images from an electron microscope are black and white because electron wavelengths are outside the range of visible light. However, artificial color is sometimes added to enhance the image.
Cost: $100,000 - $300,000

Scanning & Dissecting Microscope



GLOSSARY

amphipod A small shrimp-like animal. Most amphipods live in the ocean, though a small number live in fresh water or on land.

attain To reach, achieve, or accomplish. Tony said that he couldn't attain the depths where the seals are getting their food.

Bering Sea A body of water in the Pacific Ocean north of the Aleutian Islands. It is bordered on the east and northeast by Alaska, on the west by Russia, and on the far north by the Bering Strait.

calcium carbonate A chemical compound which is the main part of shells of marine organisms, snails, pearls and eggshells. It is also found in many rocks.

cephalopod A group of animals that includes squids, octopuses, cuttlefish, and nautiluses. Cephalopoda means "head foot." Cephalopods are mollusks, which makes them related to clams, oysters, mussels, scallops, snails, and slugs.

cephalopod beak Sharp bony mouth part of a squid or octopus.

cephalopod pen The internalized shell of a squid.

chemical contaminants Man-made chemicals that do not occur naturally in the environment. At high concentrations they can be harmful to the health of marine organisms. Examples are oil, pesticides, medicines, chemicals used to make plastic, flame retardants, and many more.

chemical fixative A chemical used to preserve tissues for further study. One type of fixative is formalin.

cilia (singular: cilium) Slender hair like structures on the surface of cells. Cilia is Latin for "eyelash." Cilia have specialized functions, they may wave to move single celled organisms like paramecium, or they may move things around the cell surface. Cilia may also be sensory; cells inside fish noses have cilia that detect odors in the water.

conductive surface A conductor is a type of material that allows the flow of electricity from particle to particle. Most metals are conductive, but plant and animal materials are not conductive. The surface of samples examined with a conventional scanning electron microscope needs to conduct electricity, so non-conductive materials (such as fish scales) are coated with a thin layer of metal to give them a conductive surface.

conservation The act of protecting or preserving natural resources in order to prevent depletion or loss.

critical point drying A process to remove water from a sample in a controlled way. Samples that contain water shrivel and wrinkle if they are air-dried. So plant and animal material must be carefully dried before being examined with a conventional scanning electron microscope. The water is replaced with liquids such as ethanol and liquid carbon dioxide, and specialized equipment slowly adjusts the pressure and temperature of the liquid carbon dioxide to its "critical point" where it becomes a gas, leaving a dry sample relatively free of distortion.

degrade To decompose or break down.

discern To perceive with the eyes or intellect; to detect. To see or recognize. Tony talked about comparing otoliths to the reference collection samples to discern the species of fish that the otolith comes from.

dissecting microscope Also called a stereomicroscope, the lenses of this microscope are arranged to produce a stereoscopic or three-dimensional image. Light is used to illuminate the surface of samples, and some models also direct light through transparent materials. This microscope is most often used to look at the surface of materials such as fish otoliths or scales. Maximum magnification of a stereomicroscope is 500x. Chris' microscope magnifies up to 60x.

duration The length of time something continues or exists.

ecosystem A community of living and nonliving things interacting together.

electron Electrons, along with protons and neutrons make up atoms. A flow of electrons is called an electrical current. Electrons are used in the scanning electron microscope to produce highly magnified images.

eye lens A transparent structure in the eye used to focus light. In fish, it is spherical (round) and it is composed of specialized fiber cells that are not digested by marine mammals.

feces Bodily waste discharged from animals; also called stool, scat, or poop.

fixed sample (see chemical fixative) A sample that is preserved with a chemical fixative.

flame retardants Chemicals that are applied to clothing or other material to prevent them from catching on fire. They can be found in many things, including televisions, mattresses, computers and pajamas.

flatfish A group of mostly saltwater, bottom-dwelling fish in which both eyes are located on the same side of the head. The underside of a flatfish is white. Many flatfish can change the color of their upper side (the side with the two eyes) to match their surroundings. The flatfish family includes flounder, sole, and halibut.

food chain Nutrients and energy are passed from creature to creature through the food chain. An example of the food chain starts with plants such as algae and diatoms. Algae use the sunlight for energy, shrimp eat the algae, fish eat the shrimp, and marine mammals eat the fish. The food chain links plants and animals within a community or ecosystem.

food web A network of food chains in an ecosystem.

foraging The act of searching and hunting for food.

formalin A chemical used by biologists to preserve tissue samples for further study. It is formaldehyde that has been diluted with water.

glutaraldehyde A chemical used to preserve tissues for further study. It is usually diluted with water or combined with other preservatives.

haulout (also see rookery) Areas on land or ice where pinnipeds (seals, sea lions and walruses) can temporarily leave the water to rest.

inner ear In humans, the inner ear is a maze of fluid filled tubes that help maintain balance. In fish, the inner ear is a maze of sacs and canals. These canals detect turning movements and sound but they also help the fish maintain the correct orientation.

leach Process where water-soluble substances move out of the original material into the water or surrounding materials. For example, in certain plastics some of the chemicals leach into water.

light microscope or compound light microscope A microscope that uses visible light and more than one lens to magnify an object up to 2000x. Light is passed through thin or transparent samples to produce two-dimensional images.

monitoring Collecting information by testing or sampling on a regular or ongoing basis.

neuromast A tiny organ composed of a few specialized cells used to sense water movement or pressure changes. They may occur individually on the surface of the fish, or may be inside pits and interconnected along the lateral line. Fish use neuromasts to swim in schools and sense when predators are near.

NMFS An abbreviation for National Marine Fisheries Service also known as NOAA Fisheries Service. NMFS is an office within NOAA dedicated to the stewardship of living marine resources through science based conservation and management, and the promotion of healthy ecosystems.

NOAA An abbreviation for the National Oceanic and Atmospheric Administration, a federal government agency in the Department of Commerce, created in 1970. NOAA scientists conduct research on the world's oceans and atmosphere.

northern fur seal An pinniped with ear flaps (an “eared seal”), long front flippers, the ability to walk on all four flippers on land, and with dense underfur. Northern fur seals are found in the North Pacific Ocean, the Bering Sea and the Sea of Okhotsk.

olfactory Of or relating to the sense of smell.

orientation A fish's position or alignment relative to its surroundings. A fish usually orients itself with its upper body towards the surface of the water and its lower body towards the bottom of the ocean.

otolith Otoliths or "earstones" are found in the heads of all fishes except sharks, rays, and lampreys. They "float" just below the brain. There are three pairs of otoliths in each fish. Only the largest pair of otoliths is used to age fish. The other two pairs are about the size of a pinhead. The otolith of each fish species has a distinctive shape. Scientists like Tony use otolith shape to identify the species of fish eaten by seals and sea lions. Humans also have otoliths called otoconia. Like otoliths in fish, otoconia are found in the inner ear and they help us maintain balance.

pesticide A chemical or substance used to keep away or destroy pests including animals, insects and plants. Common household products that contain pesticides are rat poison, personal bug spray, weed killers, kitchen and bath disinfectants, and flea and tick products.

pectoral fin The two fins found on the underside of a fish like a salmon or rockfish just behind the head.

pesticide A chemical or substance used to keep away or destroy pests including animals, insects and plants. Common household products that contain pesticides are rat poison, personal bug spray, weed killers, kitchen and bath disinfectants, and flea and tick products.

pinniped Semi-aquatic marine mammals; pinniped is Latin for “fin-foot.” Seals, sea lions and walruses are all pinnipeds.

pollutant A waste material that pollutes air, water or soil.

population A group of organisms (animals or fish) that share the same habitat.

predator A predator is an organisms that hunts and consumes its food or prey.

prey An animal hunted or seized for food.

Pribilof Islands A group of volcanic islands in the Bering Sea. The Pribilof Islands are home to the largest population of northern fur seals in the world, as well as large seabird rookeries.

range The region over which a population or species is distributed.

rockfish Rockfish are fish from the family Sebastidae. They have large scales and spines on the head, gill covers, and fins. They can live close to the bottom or in open water.

rookery (also see haulout) A colony of breeding animals. A rookery can be a nesting place for birds (especially birds that nest in large groups), or breeding grounds for pinnipeds (seals, sea lions and walruses).

runoff (also surface runoff) The water flow that occurs when water from rain, snowmelt, or other surfaces flows over the ground. Runoff can be in the form of rivers, lakes or streams, or it can occur on surfaces before reaching a channel like a stream or river. When runoff flows along the ground, it can pick up contaminants from the soil.

San Miguel Island The westernmost and sixth-largest of California's Channel Islands. San Miguel Island is part of the Channel Islands National Park.

scanning electron microscope A microscope that scans the surface of a sample with a beam of electrons. Images from this type of electron microscope have a three-dimensional appearance.

scat Bodily waste discharged from animals; also called feces, stool, or poop.

sculpin A fish that belongs to the Cottidae family. Most of these fish live in salt water (although a few species are found in fresh water), are bottom feeders, and have sharp spines, large pectoral fins, and short, tapering bodies.

sea lion A pinniped with external ear flaps, long front flippers, the ability to walk on all four flippers on land, and with no dense underfur. There are seven species of sea lions. Sea lions and fur seals make up the "eared seal" group of pinnipeds.

seal A pinniped with no external ears and a sleek, streamlined, sausage-shaped body. A seal cannot walk on all four flippers, but crawls when on land or ice. Its foreflippers are short and used mainly for steering, while the hindflippers are used for swimming.

sensory cell A cell that receives sensory input, such as smell or touch.

sieve An instrument that is used to strain or sift materials.

stereomicroscope See dissecting microscope.

sustainable fishery A fishery that can be conducted over a long period of time without causing damage to the ecosystem that would prevent fishing in the future.

vacuum A space where the air has been removed. In a conventional scanning electron microscope, samples are placed in a vacuum chamber, and the air must be removed before the sample can be examined. This is because air molecules will interfere with the electrons used to image the sample.

vertebra (plural: vertebrae) An individual bone in the backbone or vertebral column. If you run your finger down your backbone, you will feel bumps. Each of these bumps is from one vertebra.

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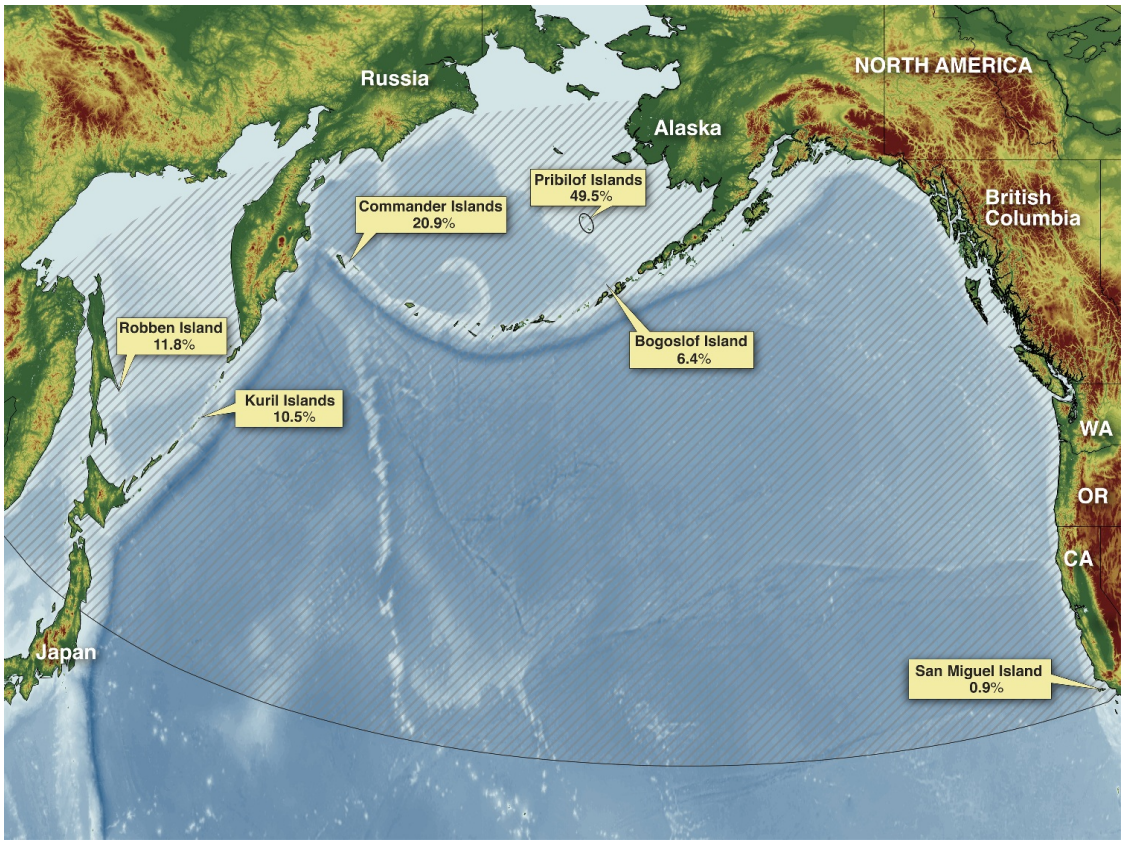
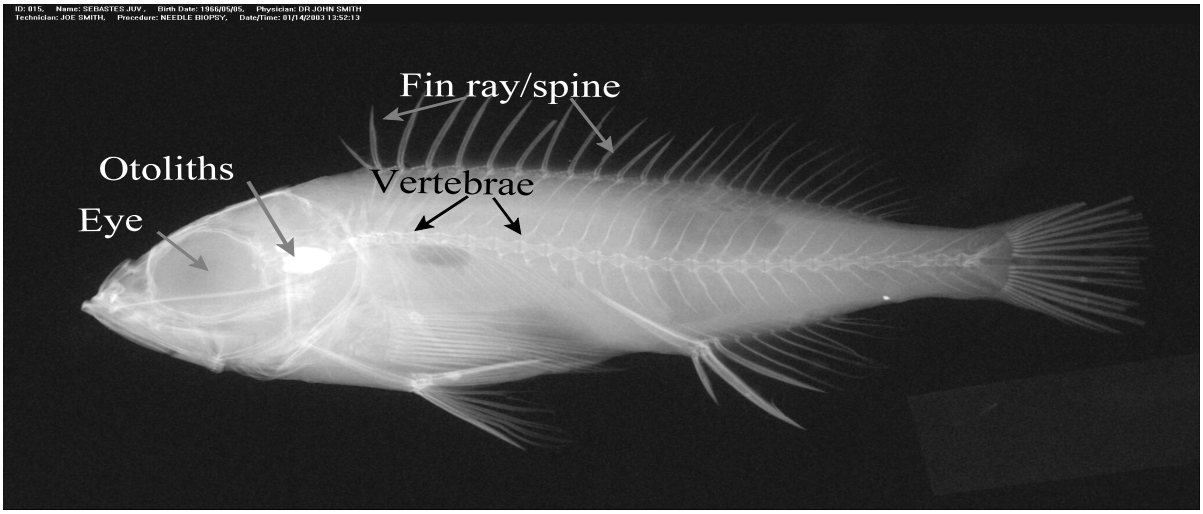
APPENDIX 1: Northern Fur Seal Range



Northern fur seals can be found at six breeding rookeries in the Pacific Ocean during the summer. Most of the population can be found in the north Pacific, with 49% on the Pribilof Islands. In early fall, the seals leave the island rookeries and spend their winters at sea.

APPENDIX 2: Xray of a fish skeleton



APPENDIX 3: Dover Sole Otolith Images

Image of otolith surface.

Image of interior surface after cooking in the toaster oven and cutting in half.

APPENDIX 4: Washington State Standards and Ocean Literacy Principles

NOAA Microworlds Videos
Educational Standards and Ocean Literacy Principles

	Subject Area(s): Life science	**Grade Levels:** 5th
	Video Topics: **1. Tony's video:** How scientists use microscopes to find out what marine mammals eat, and why it's important to know marine mammal food habits. **2. Chris' video:** How scientists use microscopes to find out how old fish are, and how the information is used. **3. Carla's video:** How scientists use microscopes to look at the effects of contaminants on fish, why it's important to know how fish are affected, and how people can help.	
Materials:	DVD with 3 videos Supplemental material (scientist biographies, frequently asked questions, resources, glossary)	
State Standards (WA: EALRs)	EALR 1: Systems, core content: complex systems. 4-5 SYSC – Systems have inputs and outputs. Changes in inputs may change the outputs. 4-5 SYSD – One defective part can cause a subsystem to malfunction, which in turn will affect the system as a whole. EALR 2: Inquiry, core content: planning investigations. 4-5 INQA – Scientific investigations involve asking and answering questions and comparing answers with evidence from the real world. EALR 3: Application, core content: different technologies. 4-5 APPH – People of all ages, interests, and abilities engage in a variety of scientific and technological work. EALR 4: Life Science (Ecosystems), core content: food webs. 4-5 LS2A – An ecosystem includes all of the plant and animal populations in a given area. Plants and animals depend on one another and the nonliving resources in their ecosystem to help them survive. 4-5 LS2D – Ecosystems can change slowly or rapidly. Big changes over a short period of time can have a major impact on the ecosystem and the populations of plants and animals living there. 4-5 LS2F – People affect ecosystems both positively and negatively.	
Ocean Literacy Principles (OLPs) and Fundamental Concepts (FCs)	OLP 5. The ocean supports a great diversity of life and ecosystems. FC 5d. Ocean biology provides many uniques examples of life cycles, adaptations and important relationships among organisms. OLP 6. The ocean humans are inextricably interconnected. FC 6e. Humans affect the ocean in a variety of ways. FC 6g. Everyone is responsible for caring for the ocean. Individual and collective actions are needed to efficiently manage ocean resources for all. OLP 7. The ocean is largely unexplored. FC 7b. Understanding the ocean is more than a matter of curiosity. Exploration, inquiry and study are required to better understand ocean systems and processes.	
Learning Objectives	After viewing these videos, students will be able to: ● Identify at least 3 jobs in which scientists use microscopes ● Explain how scientists use microscopes to find out what marine mammals eat ● Explain how scientists use microscopes to figure out the age of fish ● Explain how chemicals in the water might affect fish ● Explain how the microscopes used in the videos are similar to the ones students use in the classroom	

Ocean Literacy Principles: http://www.coexploration.org/oceanliteracy